

Application

Narrative

Cash Transmittal

Development Standards

City of Scottsdale

Indian Bend Wash Master Plan 'McKellips Road to Thomas Road'

Introduction

The City of Scottsdale is strongly committed to the continued success of Indian Bend Wash (IBW). Over the past 40 years the City has continued to make targeted improvements to the aging infrastructure and other features within the wash. These targeted improvements while addressing immediate needs and concerns did not evaluate the overall project corridors new opportunities relative to upgrading and updating the project to current needs and design standards. This master planning effort for the initial two mile section between McKellips Road and Thomas Road is the first such master planning effort undertaken by the City of Scottsdale since the project was envisioned in 1964.

The master plan design process targeted an extensive public input process focused on stakeholders and the community with a commitment to revitalizing, restoring and reinvigorating Indian Bend Wash. There were few constraints, beyond the physical characteristics of the site itself and the fact Indian Bend Wash should remain a landmark place focused on community linkages, passive and active recreation, and flood control. As a result, the redesign grew organically, based on the input of the City, stakeholders, and the public. In the end, a great number of alternatives and strategies have converged to create a visionary redesign that captures the imagination of a greatly improved public asset. A project that will help to catalyze private reinvestment along the corridor's banks, and will inspire the continued long term financial support from the City of Scottsdale in conjunction with the support gained from residents, patrons, donors, and contributors that are all eager to see Indian Bend Wash remain one of the City's most stellar recreational open space corridors.

Objectives and Goals

The objective of the master planning effort is to develop a master plan for the Indian Bend Wash (IBW) parks and lakes system between Thomas Road and McKellips Road within the City of Scottsdale.

First and foremost, the IBW Greenbelt is a multi-benefit regional flood control facility. However, much of the infrastructure of the corridor and many of the site features are reaching the end of their life cycle and are in need of replacement, rehabilitation and upgrades. This aspect is most obvious when reviewing one of the corridors most prominent features the project's Lake System. This system is comprised of several lakes (Eldorado North, Eldorado South, Vista del Camino North, Vista del Camino South, Roosevelt and McKellips) and passive low flow linkages that connect each of these major lake features. These lakes not only serve as a recreation and aesthetic component of the project but also serve as one of the major infrastructure components of the entire system where they serve as the water reservoirs used to facilitate the irrigation needs of the turf lined channel that defines IBW. These lakes and their infrastructure of wells, piping, liners and interconnected waterways all require major renovation and mitigation measures to save water and to preserve their functionality. These lakes are only one example of the many infrastructure issues that this master plan is addressing.

The goal of this master planning effort and its focus is on revitalizing, restoring and reinvigorating IBW by developing a "roadmap" for that effort. The City of Scottsdale is committed to developing a master plan that can be utilized to guide the IBW parks and lakes back to a vibrant and user friendly recreation City asset while respecting the primary corridor function of flood control. The City of Scottsdale has made the commitment to refocus its energy, economics and policies on the reestablishment of this premier public open space as a top priority for current and future generations to enjoy and cherish.

One of the primary objectives of this master planning effort is to re-establish IBW to the same level as other great linear parks that have shifted paradigms and perceptions; places like Rio Salado in Phoenix,

Central Park in New York, Olmsted's Linear Park in Atlanta and more recent parks like the High Line in New York City, the 606 in Chicago and Klyde Warren Park in Dallas. These parks are keenly focused on the need for people to connect with urban nature for the benefit of revitalizing, restoring and reinvigorating their spirit, health and connecting with their community and neighbors.

Background

In the early 1960s, The City of Scottsdale and the U.S. Army Corps of Engineers (USACE) tussled over whether IBW should be a cement-lined channel or a grass-lined greenbelt. The USACE initial plan that was congressionally approved in 1961 was a seven mile concrete channel that was on average 23 feet deep and 170 feet wide. The citizens of Scottsdale were not in favor of this approach and the City and its active citizen base created in 1964 a committee called the Scottsdale Town Enrichment Program (STEP). The STEP committee worked as an advisory group to the City council, and City departments advising them on the best approach for IBW. The STEP committee formulated a strong anti-channel message that resulted in the citizens of Scottsdale voting down a 1964 county wide flood control district bond that would have resulted in channelizing the wash. The citizens of Scottsdale in the 1970's also voted down a local sales tax increase that was targeted to fund the purchase of private property for the development of the envisioned grass lined channel. This lead the City of Scottsdale to the development of several ordinances including a floodplain ordinance that created an easement through the adjacent IBW private properties that allowed the land ownership to remain largely privately held while the majority of the actual wash became public property. The ordinance had the additional benefit of controlling encroachment into the IBW corridor. In addition to these ordinances the STEP committee recommendations for a different approach to flood control one that focused on a greenbelt not a concrete channel. This approach was supported by a feasibility study that initiated the conversations with the City of Scottsdale, USACE. congressional leaders in Washington, and many concerned and very active citizens. The combination of these efforts and many other factors resulted in federal funds being committed to the project in 1974 with the long term payback of this investment backed by the City of Scottsdale. Over the next six years the final touches to the IBW greenbelt system that we know today were finalized and resulted in the IBW corridor that is today one of the crown jewels of the City of Scottsdale.

Approach to Performing the Required Services – Project Challenges

Many of the IBW's parks and lakes within the City were constructed in the 1970's and now many of the greenbelt's facilities and related infrastructure are reaching the end of their life cycle. The existing elements within the parks, such as the lakes, low flow channels, irrigation systems, ramadas, basketball courts, baseball fields, playgrounds, splash pads, restroom facilities, and more are in need of upgrades, rehabilitation and improvements. The project challenges are multi-faceted due to the complexity and the age of the infrastructure, facilities, requirements for ADA, changes in lighting type and control, changes in modes of travel within the corridor, and other project factors that have to be addressed. To approach these challenges will require identification and prioritization of the backbone infrastructure elements and features that must be replaced due to the fact that they support much of the surrounding features and elements within IBW. The approach will be to address those infrastructure features and elements as the first and highest priority.

Lake Improvements:

One of the primary features associated with the backbone infrastructure elements of IBW is the corridors water supply and lake features. The water supply and lake features are the heart of IBW providing the water that established the aesthetic and recreational benefits while also providing the necessary and required water resource for the vegetation growth that defines the corridor. The upgrades, rehabilitation and improvements required to this major IBW infrastructure component will have a positive and long lasting impact on the project corridor. The improvements to the water supply system will be extensive providing improved efficiency, control and better monitoring of water use through this City owned and maintained system. The upgrades anticipated with these water supply systems will also result in tangible

water and energy savings due directly to the efficiency of the new equipment compared to the existing system.

The proposed lake improvements will be vast and extensive and will include but not limited to upgrading the lakes to modern standards with regards to City equipment for irrigation delivery and water supply, meeting federal and state water quality mandates/requirements, reduction of water seepage with improved liner materials, reduction in erosion water loss through improved lake edges, improved lake depths for water quality and volume, improved aeriation and circulation, increase efficiency, ease of maintenance, and enhanced aesthetics. These planned improvements to each of IBW's water supply wells, pumps, lakes and their associated infrastructure has a direct and corresponding effect on the lake itself and the surrounding irrigation system and the landscape that they sustain. The improvements should result in increased efficiency in their respective operations and cost savings associated with improved monitoring, efficiencies and maintenance.

Dam Improvements

Repairing the dam and improving the esthetics of the existing levee at McKellips Lake is another one of the main components of the entire IBW water supply and delivery systems that will have multiple benefits to IBW. The current dam is leaking and has resulted in water levels in the lake having to be reduced to minimize water loss through the dam. This water reduction has resulted in additional degradation of the lake liner and edge system and water quality. The upgrades and updates to this lake system and the associated dam will result in significant cost savings that will include but not be limited to the following:

- 1. Immediate elimination of dam leakage onto adjacent public walkways
- 2. Reduced water usage with new dam, improved lake liner and edge treatments
- 3. Significant improvement in water quality and reduction to water treatment cost due to the enhancements involving a greatly improved lake aeration and circulation system thus reducing the need for heavy chemical use and the manual removal of algae and other undesirable plant growth that is a direct result of poor water aeration or circulation.
- Improved lake edge aesthetics and corresponding reduction in maintenance and reduction in water loss

Civil Improvements Benefits:

The proposed civil improvements throughout the IBW corridor vary from mile to mile but in general, the improvements provide many benefits including but not limited to:

- 1. Upgrading pathway widths improvements will widen the IBW pathways to better accommodating the diversity of users such as runners, bikers, users with strollers and wagons, scooters, and users with disabilities:
- 2. Upgrading the irrigation system to minimize the overspray of irrigation water onto the adjacent IBW multi-use pathways;
- Improved storm water drainage systems that will drain the areas that experience frequent standing water thus reducing the potential hazard to park users, improves vector control, and increases the longevity of the concrete and asphalt that is often inundated by the storm water flows;
- 4. Improving the conditions of the open low-flow channel connector system between the lakes the improvements envisioned will improve the open channel by deepening the channels wherever possible, creating a stable edge treatment, and investigating a more stable and secure lining system.

Landscape & Hardscape Improvements Benefits:

The portion of the IBW Greenbelt that is being master planned is an oasis of parks, lakes, and paths traversing 2 miles north from McKellips Road up to Thomas Road through the heart of Scottsdale. It has been well proven by numerous studies that open space and parks improve property values. There is a significant link between the increased value of a property and its proximity to parks, greenbelts and other

green spaces. Indian Bend Wash is a prime example of how a park development can transform an area. The result of the improvements within and adjacent to Indian Bend Wash are well documented and the corridors positive effects on the community can be seen in the high daily use of the corridor and the quality and diversity of the developments that surround and link into the Indian Bend Wash corridor.

The programmed improvements included will not diminish the positive effects that Indian Bend has on the surrounding social and economic environment. The improvements envisioned as part of this master plan addresses numerous components associated with IBW in a general fashion. These improvements include but would not be limited to the following;

- 1) Improved pathway widths to accommodate the diversity of users and varying modes of travel
- 2) Improved lake infrastructure (liners, edge treatments, aeriation, circulation)
- 3) Improved dam at McKellips Lake
- 4) Improved tree planting and tree replacement strategy
- 5) Improved parking and corridor access
- 6) Improved public access throughout the corridor
- 7) Improved lighting throughout the corridor
- 8) Improved restrooms and public facilities
- 9) Improved picnic ramadas
- 10) Improved skate plaza elements and features
- 11) Improved play equipment for inclusive play of all abilities
- 12) Incorporation of new splash pad features
- 13) Improved sport courts
- 14) Improved dog park
- 15) Improved lake access for public use and enjoyment

Irrigation Improvements Benefits:

The IBW is defined by many as a "greenbelt" due to the vast swaths of lush green grass that envelope the corridor. This grass not only defines IBW it is a key component in this facility's ability to safely, effectively and efficiently control the flood waters that flow within the IBW banks. The turf that both defines and creates the flood control channel that is IBW is only possible due to an intricate and connected irrigation system. A well maintained irrigation systems has a finite service life. Typically a 30 year old irrigation system is considered a good return for the investment. Pump systems have a much shorter service life due to the nature of that equipment and its daily use, usually in the 10 to 15 year range. The IBW irrigation and pump systems are far beyond these typical ranges and in need of replacement. There are multiple benefits that can be had through the installation of a new irrigation, pump and control system for IBW. These include but would not be limited to:

- Lower water use as the irrigation system wears out the equipment loses its efficiency and accuracy. A new irrigation system designed correctly can result in significant water savings.
- 2. A new state of the art turf irrigation system can reasonably be expected to save 10 to 15 percent of water per year compared with the old system. Lower electrical power use the new pump systems are much more efficient than those manufactured in the past. The use of variable frequency drives (VFD) that slow down the pump motors to only the speed necessary to meet the irrigation demand can save as much as 30% in electrical usage. Older pump systems were sized for maximum demand and would always run at that capacity no matter if the system required that volume or not. The newer VFD pumps measure the volume flow and pressure and operate at only the level necessary to maintain the pressure and flow demand. Irrigation systems demand is constantly changing and is rarely at 100% except for short periods.
- 3. Shorter water windows A properly designed irrigation system can be programmed to deliver the required water in less time during the evening hours when evaporation is at its lowest and the

- park facilities are not in use. Typically water windows of 6 hours (10 pm to 4 am) can be maintained. This allows for maximum use of the park facilities.
- 4. Elimination of potable water use There are opportunities for the City of Scottsdale to partner with the School District and evaluate the possibility of converting the multi-use fields at Yavapai Elementary School from the potable water supply at the school to the new lake water system on the adjacent Vista Del Camino South Park. This will eliminate the use of approximately 50 acre feet
 - (16,292,550 gallons) of potable water use and the associated high water cost from the school budget annually.
- 5. Multi-use fields will be more playable a new irrigation system will generate higher quality turf in less run time (shorter water window). This will result in more playable fields that can be used for more hours per week.
- 6. An irrigation system design that minimizes pathway overspray
- 7. An irrigation system designed to provide supplemental and deep water to existing trees that have become accustomed to water from leaking lakes and channels

Landscape Design Theme

The landscape design theme for the project is twofold, the primary focus will be to build upon the success of the existing vegetation and then to focus new plantings that help to reinforce the existing while building towards a "Southwest Desert Oasis" landscape theme influenced by the confluences of the IBW with its wide swath of open greenery of existing mature trees that will be protected in place along with a mixture of native (where feasible) and subtropical plant materials. The landscape design theme emphasizes transparency in the planting design which takes on a more structured pattern approach with a combination of plant material and hardscape elements. Collectively, these well-adapted plants create a distinctive Southwest Desert Oasis look that connects the Indian Bend Wash plant palette to the Southwest region's natural landscape and climate. The palette of selected plant material will be grouped and arranged to create interesting patterns, flowing lines, open spaces, textures, color combinations, and structured design forms. Inert hardscape material arrangements will include a more intensified use of color, textures and patterns which heighten the organization of the planting design, further enhancing the lush landscapes of the existing IBW corridor/character area.

Sustainability principles will be integrated in the landscape design reflected in the use of salvaged trees, new arid low water using plants and a selected mixture of semi-tropical and riparian plants. The master plan will identify the use of water harvesting principles, low impact development components, along with selective use of decomposed granite and angular crushed rock used as ground plane surfacing materials in planting areas, swales, and berms in an effort to promote a water conserving landscape. All the plant material listed on the Arizona Department of Water Resources low water use plant list combined with the City's Design Guidelines with specific attention to the unique urban character of the IBW will be applied to this corridor.

Existing Mature Trees

Indian Bend Wash is lined with mature trees some that have root systems directly connected to the lakes and low flow channels. Concerns regarding the longevity of these trees once they have been "cut off" from the leaking lakes and channels remains a concern and a design issue. Selective tree removals may be required from the lakes and channel edges as that interface is critical for the integrity of the liner system, water quality, and the safety of the public. There are many existing trees that were planted during special events as well as memorials and special care/coordination will be required when evaluating any tree's potential removal and or replacement. The lakes and low flow channels geometry will be designed in a manner as to minimize the impact to existing healthy trees wherever possible and the new irrigation system will be designed to supplement these trees with the water that they have become accustomed to utilizing.

Parking

Parking for recreational and open space has several standards that are applied when there are organized sports that are being accommodated (60-70 cars per field). Within IBW there is such a wide diversity of uses from passive walking, disc golf, bird watching, bicycling, to active soccer, softball, and baseball that the standards for organized sports do not address the unique nature of IBW parking. The master plan was developed based upon field observations and staff history that indicate the parks current parking is insufficient. There are a number of existing parking areas that are also not efficiently designed and lack the necessary space to adequately accommodate the size and number of vehicles that are now frequenting the corridor. The master plan indicates that parking can be greatly improved through a wide variety of approaches including improving existing parking areas, expanding them where feasible, and adding parking areas in strategic new areas. The targeted parking improvements shown on the master plan will need further refinement once a more detailed survey can be obtained and the existing and new parking areas can be evaluated.

Lighting

J2 Engineering and Environmental Design (J2) was retained to complete a lighting evaluation for the Indian Bend Wash Master Plan. The Indian Bend Wash is a flood control project that traverses 11 miles through the City of Scottsdale, Arizona, containing pathways, parks, lakes, and golf courses.

J2's lighting evaluation focuses on a two (2) mile segment of the Indian Bend Wash, between McKellips Road and Thomas Road.

J2 developed a technical memorandum in regards to our lighting effort that evaluated existing local and national lighting requirements, identify areas along the study segment that does not provide adequate lighting, and to provide recommendations for the future lighting design along this study segment. That technical memo is attached to the end of this submission document.

Permitting/Drainage Engineering

Indian Bend Wash serves as the primary drainage corridor for the City of Scottsdale. The watershed is over 100 square miles and also includes portions of Phoenix, Paradise Valley, Salt River Pima-Maricopa Indian Community, and Tempe. In the 1970's, the City designated the wash as a grass-lined flood-control channel. In the late 70's through to the mid 80's, USACE constructed levees along the channel in critical areas to bolster the flood control aspect of the channel.

There have been multiple major hydrologic and hydraulic studies of the channel completed by the FCDMC. Most recently, the Lower Indian Bend Wash Area Drainage Master Study (LIBW ADMS) was completed in 2018 and encompasses the subject reach of Indian Bend Wash. Upstream studies include Middle Indian Bend Wash ADMS and the East Shea ADMS. The studies consist of hydrology and hydraulics using FLO-2D modeling software.

Indian Bend Wash contains multiple Federal Emergency Management Agency (FEMA) Flood Zones, including Zone AE Floodway, Zone AE 100-year floodplain, Zone X protected by levee, and Zone X 500-year floodplain. Table 1 shows the effective peak flows for Indian Bend Wash at the subject reach.

Table 1 - Summary of Discharges		Peak Discharges (cfs)			
Flooding Source and Location	Drainage Area (Sq. Miles)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Indian Bend Wash at Indian School Rd	100	4,000	14,000	20,000	43,000

Per FEMA requirement, proposed improvements will have to maintain or improve historic flooding conditions in terms of water surface elevations and floodplain extents. In addition to the FEMA requirements, coordination with USACE is required. Minimum levee freeboard must be maintained as

well. The proposed improvements will require excavation within a jurisdictional water of the US. Therefore, it is anticipated that a 401/404 and 408 permits will be required for the project.



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October 29, 2018

To: Mr. Jeremy Richter Capital Project Manager City of Scottsdale 7447 E. Indian School Rd., Ste 205 Scottsdale, AZ 85251

From:

Mark Poppe, PE

Job Number:

18.1135

RE:

Lighting Evaluation

Indian Bend Wash Master Plan McKellips Road to Thomas Road

INTRODUCTION

J2 Engineering and Environmental Design (J2) was retained to complete a lighting evaluation for the Indian Bend Wash Master Plan. The Indian Bend Wash is a flood control project that traverses 11 miles through the City of Scottsdale, Arizona, containing pathways, parks, lakes, and golf courses.

This lighting evaluation focuses on a two (2) mile segment of the Indian Bend Wash, between McKellips Road and Thomas Road. See figure 1 for vicinity map.

The objective of this technical memorandum is to evaluate existing local and national lighting requirements, identify areas along the study segment that does not provide adequate lighting, and to provide recommendations for the future lighting design along this study segment.

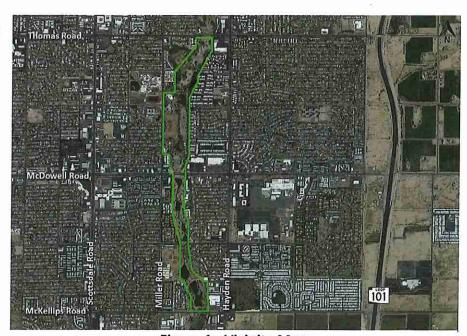


Figure 1 - Vicinity Map



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PATHWAY LIGHTING DESIGN GUIDELINES

Roadway Lighting (ANSI/IES RP-8-14)

The Illuminating Engineering Society's (IES) publication Roadway Lighting (ANSI/IES RP-8-14) is commonly used by many public agencies as the basis for establishing the appropriate lighting level design values for lighting of roadway segments, intersections, bikeways, and pedestrian ways.

The ANSI/IES RP-8-14 criteria for lighting design guidelines are based upon the roadway classification and the type of pedestrian conflict area. The three classifications for the pedestrian conflict areas are listed below:

- High Areas with significant numbers of pedestrians expected to be on the sidewalks, or crossing
 the streets during darkness. Examples are downtown retail areas, near theaters, concert halls,
 stadiums, and transit terminals.
- Medium Areas where lesser numbers of pedestrians utilize the streets at night. Typical are
 downtown office areas, blocks with libraries, apartments, neighborhood shopping, industrial,
 parks, and street with transit lines.
- Low Areas with very low volumes of night time pedestrian usage. These occur in any of the cited roadway classifications but may be typified by suburban streets with single family dwellings, very low density residential developments, and rural or semi-rural areas.

The ANSI/IES RP-8-14 recommended horizontal and vertical lighting design values for the high, medium, and low pedestrian conflict areas are presented in Table 1, Table 2 and Table 3 respectively.

Table 1 - ANSI/RP-8-14 Recommended Values for High Pedestrian Conflict Areas

Maintain Illuminance Values for Walkways				
	E _{avg} (lux/fc)	EV _{min} (lux/fc)	E _{avg} /E _{min} (lux/fc)	
Mixed Vehicle and Pedestrian	20.0/2.0	10.0/1.0	4.0	
Pedestrian Only	10.0/1.0	5.0/0.5	4.0	



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Table 2 - ANSI/RP-8-14 Recommended Values for Medium Pedestrian Conflict Areas

Maintain Illuminance Values for Walkways				
E _{avg} (lux/fc) EV _{min} (lux/fc) E _{avg} /E _{min} (lux/fc)				
Pedestrian Areas	5.0/0.5	2.0/0.2	4.0	

Table 3 - ANSI/RP-8-14 Recommended Values for Low Pedestrian Conflict Areas

Maintain Illuminance Values for Walkways				
	E _{avg} (lux/fc)	EV _{min} (lux/fc)	E _{avg} /E _{min} (lux/fc)	
Rural/Semi-Rural Areas	2.0/0.2	6.0/0.06	10.0	
Low Density Residential Areas (2 or fewer dwellings units per acre)	3.0/0.3	0.8/0.08	6.0	
Medium Density Residential Areas (2.1 to 6.0 dwellings units per acre)	4.0/0.4	1.0/0.1	4.0	

The values provided in the tables above are utilized for pedestrian areas located within the right of way. In addition to providing guidance on the travel ways, a key element for pedestrian and bicycle lighting includes the consideration of safety and security to the users.

Generally, the study section of Indian Bend Wash provides low pedestrian conflict as the pathway dissects landscaped portions of the wash, with the landscaping providing a separation between the pathway and roadways. However, the study section of the pathway does provide crossings of roadways at Roosevelt Street and Murray Lane, and provides connections to existing parking lots. Therefore, these locations may require consideration of the high and medium pedestrian conflict area criteria.

AASHTO Roadway Lighting Design Guide

The American Association of State Highway and Transportation Officials (AASHTO) Roadway Lighting Design Guide provides a basis for establishing appropriate lighting level design values for roadways, sidewalks, and pedestrian ways and bicycle ways. Roadway lighting design criteria is typically dependent upon the functional classification of the roadway and the general land uses adjacent to the roadway. The minimum lighting design values for the illuminance method is dependent upon the pavement type or reflectance.



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The recommended minimum maintained lighting design values for illuminance along pedestrian ways and bicycle ways are provided in **Table 4**.

Table 4 – AASHTO Illuminance Design Values

		Average Maintai	ned Illuminance		Illuminance Uniformity Ratio
	R1 (fc) (min)	R2 (fc) (min)	R3 (fc) (min)	R4 (fc) (min)	avg/min (max)
Pedestrian Ways	1.4	2.0	2.0	1.0	2.4
and Bicycle Ways	1,4	2.0	2,0	1.8	2;1

Of the four pavement types, R1 represents a Portland cement concrete surface. The study section of the Indian Bend Wash pathway is primarily a concrete surface. Therefore, the illuminance design values for the R1 surface shown in **Table 4** would represent the most appropriate lighting design values for the study section of Indian Bend Wash.

LIGHTING FOR DESIGN FOR MIDBLOCK CROSSINGS

The FHWA Informational Report on Lighting Design for Midblock Crosswalks (FHWA-HRT-08-053) was published in 2008. The report provides information on lighting parameters and design criteria that should be considered when installing fixed roadway lighting for midblock crosswalks. Pedestrian visibility distance is defined in the report as the distance at which a driver can see a pedestrian well enough in order to be able to respond appropriately to the pedestrian's presence. The report identifies that the greater the visibility distance, the more time a driver will have to react to the pedestrian before a conflict occurs. The report notes that, at night, luminance contrast is the primary means by which an object is detected, and therefore, providing adequate luminance is the basis for roadway lighting design.

Several factors that affect the luminance contrast between pedestrians and their visual backgrounds are identified in the report, which includes: fixed roadway lighting, headlamp lighting, pedestrian clothing, and the characteristics of the visual backgrounds. The visual background for most roadway pedestrian crosswalks consist of the roadway pavement surface and the environment surrounding the roadway. The report states that bright roadway surfaces or bright off-road installations, such as gas stations, bank, or shopping centers, increase background luminance and reduce contrast, making pedestrian detection more difficult. The lighting design level for pedestrian crossings should provide adequate lighting, even with a bright background. Typically, the brighter the background, the higher the vertical illuminance required in order for a driver to clearly see a pedestrian in a crosswalk.

The findings in the report are based on experiments of driver performance with regard to the detection of pedestrians in midblock crossings. The report utilizes vertical illuminance is the primary metric for the evaluation for the efficiency of the lighting system. Vertical illuminance is described as the illuminance on a vertical surface. The research considered in the report is based on measurements of the vertical illuminance on an object 5 feet above the road surface.



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The report's findings indicate that a vertical illuminance level of 20 lux (approximately 2 fc), measured at a height of 5 feet from the roadway surface, allowed drivers to detect pedestrians in midblock crosswalks at adequate distances under rural conditions. Furthermore, a higher level of vertical illuminance may be required for crosswalks when there is glare from opposing vehicles, the crosswalk is located in an area with high ambient light levels, or when the crosswalk is located at a lighted intersection.

To illuminate the side of the pedestrian facing an approaching vehicle, this research suggests the luminaires be installed at least 10 feet in advance of the crosswalk. Additionally, the research notes that the luminaire selected will influence the best mounting height and location of the luminaire, with respect to the crosswalk.

PARKING LOT LIGHTING DESIGN GUIDELINES

The Illuminating Engineering Society's (IES) publication *Lighting for Parking Facilities* (IES RP-20-14) provides recommendations for interior and exterior lighting practices for vehicular and pedestrian traffic in parking facilities. IES RP-20-14 provides illuminance recommendations for parking lots and parking garages. The recommended maintained illuminance values for parking lots are shown in **Table 5** below.

Table 5 - RP-20-14 Recommended Values for Parking Lots

R4 (Asphalt) Surfaces	Recommended Maintained Illuminance Targets				
1Z4, LZ3, LZ2, and LZ1*	Horizontal Targets E _h (lux/fc) (min)	Vertical Targets E _v (lux/fc) (min)	E _{max} /E _{min} (fux/fc)		
Pre-curfew	5.0/0.5	2.5/0.24	15:1		
Post-curfew	2/0.19	1/0.095	15:1		

^{*}Lighting Zones based on ambient lighting

IES RP-20-14 provides recommended illuminance values for both asphalt and concrete surfaces, which are also based upon the surrounding ambient lighting. The recommended minimum illuminance values shown in **Table 5**, for R4 (asphalt) surfaces, and are based on lighting zones with low to high ambient lighting. Located along the study segment of the Indian Bend Wash is sports field lighting and roadway lighting. Therefore, some level of ambient lighting will be provided within the area.

Along the study segment, all identified public parking lots were constructed with an asphalt surface.

CITY OF SCOTTSDALE DESIGN GUIDELINES

City of Scottsdale's Design Standards & Policies Manual (DSPM), provides guidance and standards on street lighting in Chapter 5. Section 5-11.100 states that street lighting in the City is divided into three main lighting types (Rural, Suburban, and Urban):



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- Rural Areas Including ESL areas as defined by the city and areas with adjacent zoning intensity of
 less than 2 dwelling units per acre. These areas may also include smaller locations of more intense
 development but maintain rural development characteristics. Generally, has Limited Street
 lighting focusing only on conflict points (intersections & Pedestrian crossings) and significant
 curves (at or below the design speed).
- Suburban Street Lighting All other areas not otherwise specifically defined by the city. Generally,
 has partial lighting focusing on conflict points, significant curves (at or below the design speed) as
 well as moderate corridor lighting but does not require photometric analysis. Standards such as
 IESNA are not significantly considered.
- High Pedestrian Urban Activity Areas Generally, has full lighting, focusing on conflict points, significant curves (at or below the design speed) as well as corridor lighting and may require photometric analysis especially at critical conflict locations such as crosswalks. Standards such as IESNA are considered in the design process.

Per Appendix 5-11C, the two (2) mile segment of the Indian Bend Wash, between McKellips Road and Thomas Road is categorized under the Suburban Street Lighting area.

Furthermore, the City of Scottsdale's DSPM provides illumination requirements for street lighting based upon roadway classification. Per section 5-11.400, when photometric calculations are performed, the illuminance method is to be used.

Currently, required illumination levels are not provided for dedicated pedestrian pathways/trails by the City of Scottsdale.

NEARBY CITY DESIGN GUIDELINES

City of Tempe

According to the City of Tempe's Zoning and Development Code, Section 4-803(D)(6), "[e]xterior pedestrian pathways and adjacent landscape areas within twenty (20) feet of the pathway shall be illuminated from dusk to dawn, with one-half (0.5) foot-candle of light at finish grade."

Additionally, Section 4-803(D) (9) of City of Tempe's Zoning and Development Code provides parking lot lighting design guidance. From dusk to dawn, parking spaces shall be illuminated with two (2) footcandles, and parking lot drive aisles shall be illuminated with one (1) foot-candle.



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City of Mesa

In accordance with the City of Mesa's 2017 Engineering & Design Standards, Section 906.02 states that the City designs lighting per the RP-8-00. Section 906.11 indicates that, "[s]eparate calculations for the pedestrian areas are not required, even if the pedestrian sidewalk is separated from the street curb."

EXISTING LIGHTING CONDITIONS

Data Collection

J2 performed a field review to document the existing lighting provided along the 2-mile study segment of the Indian Bend Wash pathway, and its corresponding parking lots. The general locations, spacing, and mounting heights of the poles were documented.

The poles located along the pathway are typically spaced between 75 feet and 85 feet. The poles were generally measured to a height of approximately 16 feet. Two (2) luminaire housings were primarily observed to be utilized throughout the two (2) mile segment of Indian Bend Wash. Both luminaires appear to be high pressure sodium (HPS) fixtures.



Figure 2 - Luminaire Housing - Type A



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Figure 3 - Luminaire Housing - Type B

As previously mentioned, along the study segment, all identified public parking lots were constructed with an asphalt surface.

Based on the field review, there is an inconsistency with lighting in the parking lots along the study segment of the Indian Bend Wash. Various luminaires and mounting heights were documented in the parking lots located throughout the study segment. Luminaire types that were observed include: cobra head, shoebox, prismatic fixtures, along with the pathway style fixtures found along the trail. Additionally, some parking lots were found to be utilizing LED luminaires.

Midblock Crossings

The study section of the Indian Bend Wash pathway provides two (2) midblock crossings of roadways, which are located along Roosevelt Street and Murray Lane.

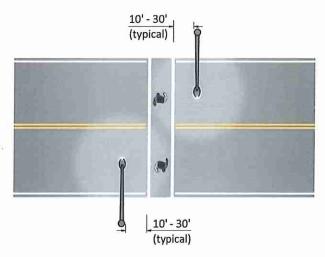
The Roosevelt Street crossing provides two (2) pathway lights, one (1) located approximately 50 feet south of the crosswalk, and the other located approximately 30 feet north of the crosswalk. Additionally, a street light is located approximately 30 feet to the east of the crosswalk, which utilizes a cobra head luminaire.



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The Murray Lane crossing provides a pathway light, approximately 55 feet north of the crosswalk, and an additional pathway light approximately 40 feet south of the crosswalk. Additionally, a roadway light is mounted to an overhead power pole, approximately 25 feet south of the crosswalk.

The existing midblock crossings do not conform to the recommendations in the FHWA-HRT-08-053 publication.



 EV_{avg} (lux/fc) = 20.0/2.0

Figure 4 - Recommended Midblock Crossing Lighting

PATHWAY LIGHTING ANALYSIS

Lighting design calculations are typically performed using computer programs. For the purposes of this analysis, AGi32 was utilized to calculate the existing light levels along a typical section of the Indian Bend Wash. The values for the average and uniformity of the light levels are the primary measurements for assessing the adequacy of the existing lighting.

The lighting analysis for the pathway was based on a typical 80 foot spacing of light poles. A calculation zone was set between the centers of two poles. The lighting analysis was based upon a 150W HPS luminaire, mounted at a height of 16 feet. Additionally, a lamp lumen depreciation factor (LLD) of 0.90, and a luminaire dirt depreciation (LDD) factor of 0.90 was assumed, resulting in a light loss factor (LLF) of 0.81. Horizontal and vertical illuminance calculation grids were located with a point spacing of 2 feet. The vertical illuminance calculation grid was located in the center of the pathway, and was 5 feet in height. The typical calculation zones is shown in **Figure 5**.



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Based upon these values, the horizontal and vertical illuminance values for a typical 80' segment is shown in **Table 6** below.

Table 6 – Lighting Analysis Results (Typical 80' Segment)

	Horizontal Illuminance (fc)	Vertical Illuminance (fc)
Average	2.42	1.41
Maximum	11.2	5.7
Minimum	0.6	0.2
Avg/Min	4.03	7.05

The average horizontal illuminance of 2.42 foot-candles exceeds the ANSI/IES RP-8-14 and the AASHTO Roadway Lighting Design Guide's recommended horizontal illuminance values. Additionally, the average vertical illuminance exceeds the ANSI/IES RP-8-14 recommended illuminance values, for all conflict area types. The uniformity ratio satisfies the recommended values per the ANSI/IES RP-8-14, however is larger than the AASHTO uniformity ratio of 3:1, and therefore does not meet this standard.

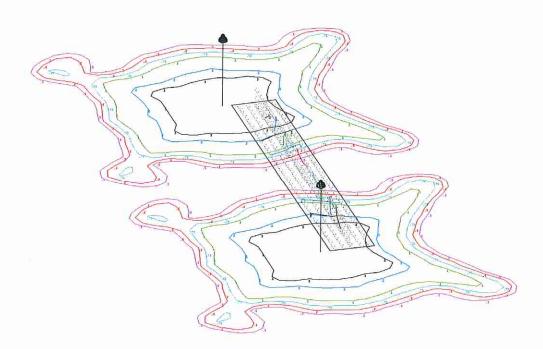


Figure 5 - Typical 80' Calculation Zone

PARKING LOT LIGHTING ANALYSIS

Due to the inconsistencies with the luminaires and mounting heights observed in the parking lots along the two (2) mile study segment, a specific lot was chosen for the analysis. The parking lot located along



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Roosevelt Street, approximately 650 feet east of 76th Street, was chosen for the analysis. Four (4) light poles are provided in this parking lot, with luminaires similar to those that are found along the pathway. This parking lot was chosen based on the mounting heights of the luminaires, with a mounting height of approximately 16 feet, which was found to be the lower mounting heights of luminaires in parking lots along the study segment of the Indian Bend Wash. Lower mounting heights generally provide a less uniform light level. Therefore, this lot may be considered the least favorable condition, from a lighting perspective.

A horizontal illuminance calculation grid was located within the parking lot, as well as two (2) vertical illuminance calculation grids, providing lighting levels for each direction of travel. The vertical illuminance calculation grids were located in the vehicle travel way, perpendicular to both directions of travel. The calculation zones for the parking lot is shown in **Figure 6**.

Table 7 – Lighting Analysis Results (Parking Lot)

	Horizontal Illuminance (fc)	Vertical Illuminance (fc) - Direction 1	Vertical Illuminance (fc) - Direction 2
Average	1.32	0.94	0.61
Maximum	15.1	1.7	1.5
Minimum	0.2	0.4	0.3
Max/Min	75.5	4.25	5.0

The minimum horizontal illuminance of 0.2 foot-candles falls below the IES RP-20-14 recommendation for a horizontal illuminance minimum of 0.5 foot-candles for pre-curfew conditions. However, the minimum vertical illuminance values, for both directions, exceed that of both pre- and post-curfew recommended vertical illuminance values. The maximum to minimum ratio for horizontal illuminance is larger than the recommended value of 15:1, and therefore does not meet this standard.



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Figure 6 - Parking Lot Calculation Zone

RECOMMENDATIONS AND CONCLUSIONS

This lighting evaluation focuses on a two (2) mile segment of the Indian Bend Wash, between McKellips Road and Thomas Road. The objective of this technical memorandum is to evaluate existing local and national lighting requirements, identify areas along the study segment that does not provide adequate lighting, and to provide recommendations for the future lighting design along this study segment.

A lighting analysis was completed utilizing AGi32 to calculate the existing light levels along a typical section of the Indian Bend Wash. The analysis revealed that a horizontal illuminance value of 2.42 footcandles is observed along a typical 80' segment of the Indian Bend Wash, which exceeds the ANSI/IES RP-8-14 and the AASHTO Roadway Lighting Design Guide's recommended horizontal illuminance values. Additionally, the average vertical illuminance exceeds the ANSI/IES RP-8-14 recommended illuminance values, for all conflict area types. The uniformity ratio satisfies the recommended values per the ANSI/IES RP-8-14 recommended values.



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It is recommended that future path lighting be designed to comply with the RP-8-14 values of:

$$E_{avg}$$
 (lux/fc) = 20.0/2.0
 EV_{min} (lux/fc) = 10.0/1.0
 E_{avg}/E_{min} (lux/fc) = 4.0

This will comply with RP-8-14 for mixed vehicle and pedestrian in high conflict areas, and still be comparable to the existing path lighting.

Providing a consistent LED fixture for each pole throughout the 2-mile study segment of Indian Bend Wash would provide a uniform appearance. Additionally, selecting the appropriate LED luminaire may improve the uniformity along the pathway, and thereby may provide an improved sense of security at night for path users.

It is recommended that the roadway lighting near at-grade crossings of the Indian Bend Wash pathways be located in accordance with the recommendations in the FHWA *Informational Report on Lighting Design for Midblock Crosswalks*.

Parking lot lighting, throughout the 2-mile study segment of the Indian Bend Wash, provides inconsistencies in the luminaires, poles, and mounting heights provided. Therefore, providing a standard luminaire throughout the parking lots located along Indian Bend Wash, if desired, may provide easier maintenance. However, mounting heights of the luminaires will need to be analyzed on a case-by-case situation, in order to insure that adequate lighting is being provided in each parking lot.

It is recommended that future parking lot lighting be designed to comply with RP-20-14 values for precurfew conditions:

Horizontal Targets
$$E_h$$
 (lux/fc) (min) = 20.0/2.0
Vertical Targets E_v (lux/fc) (min) = 10.0/1.0
 E_{max}/E_{min} (lux/fc) = 15:1

